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Crawford et al.

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(54) **DISTAL TIPS FOR MEDICAL DEVICES**

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CPC ***A61B 1/018*** (2013.01); ***A61B 1/00091*** (2013.01); ***A61B 1/00101*** (2013.01);
(Continued)

(58) **Field of Classification Search**
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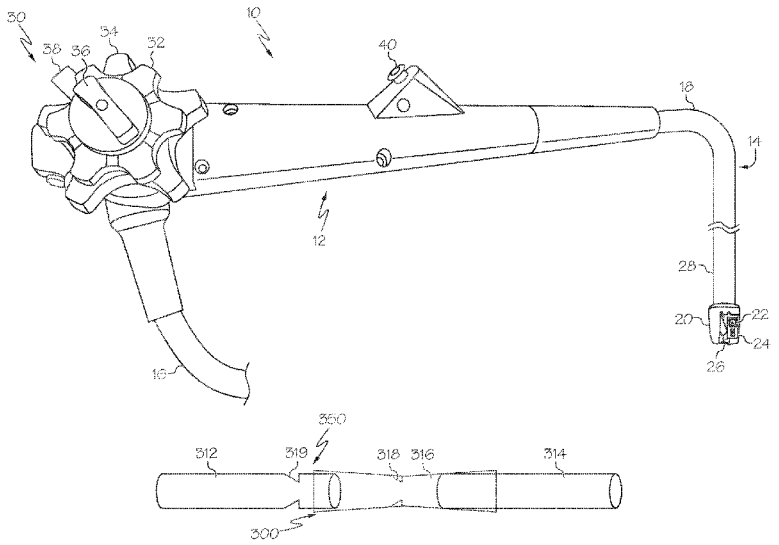
(57) **ABSTRACT**

A medical device may comprise a distal tip having a viewing element, a lighting element, and at least one feature configured to removably couple the distal tip to a shaft. The medical device may also comprise a working channel coupled to the distal tip and defining a central lumen configured to receive a tool. A wall of the working channel may define at least one additional lumen. The working channel may be configured to be removably inserted into the shaft. The medical device may also comprise at least one of a wire, a cable, or a conduit passing through the at least one additional lumen.

13 Claims, 11 Drawing Sheets



(51) **Int. Cl.**
A61B 1/018 (2006.01)
A61B 1/05 (2006.01)
A61B 1/06 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 1/0057*** (2013.01); ***A61B 1/05*** (2013.01); ***A61B 1/0676*** (2013.01)

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See application file for complete search history.

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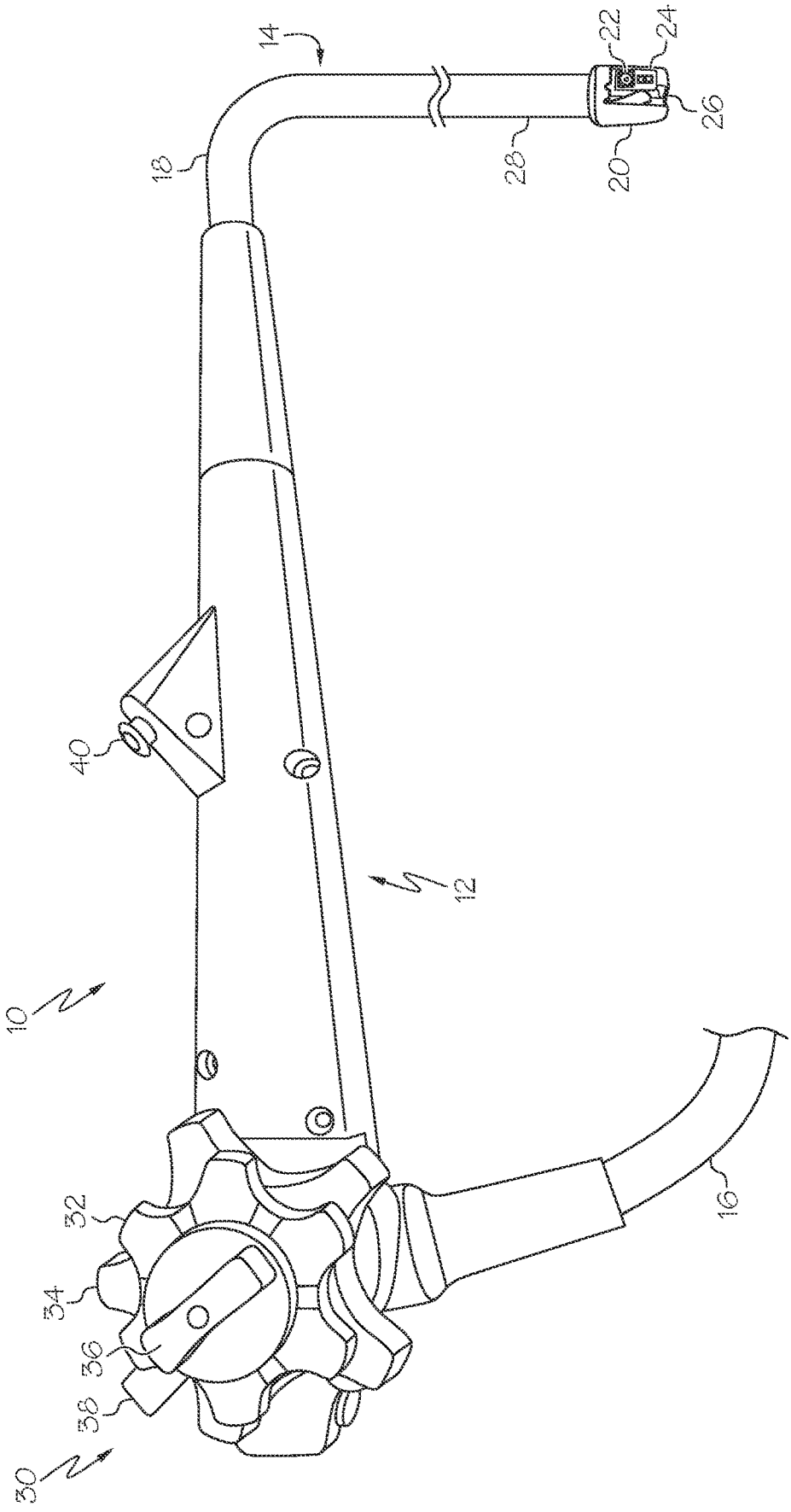

FIG. 1

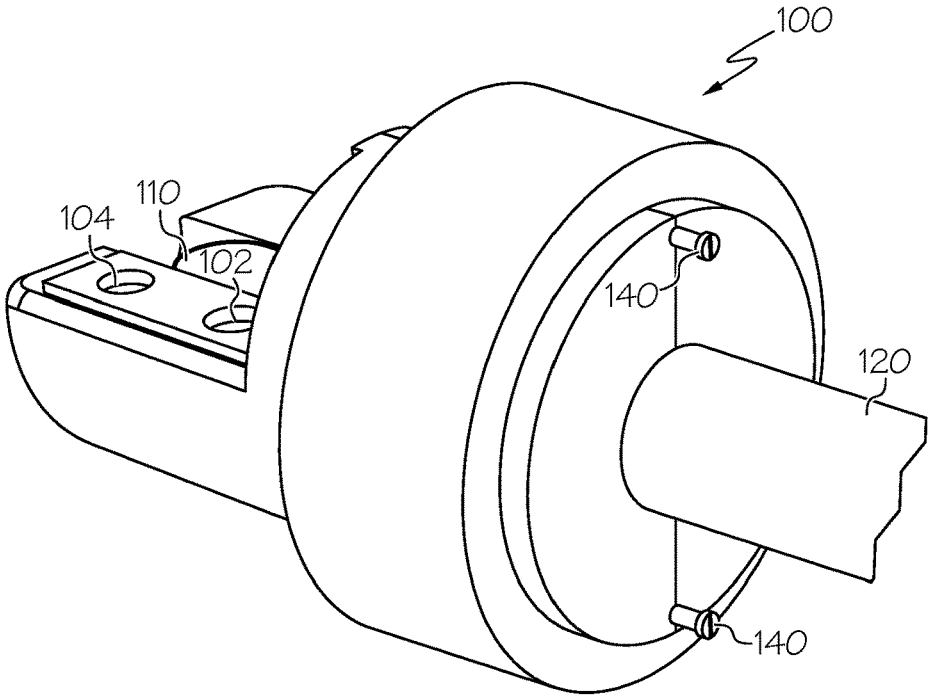

FIG. 2A

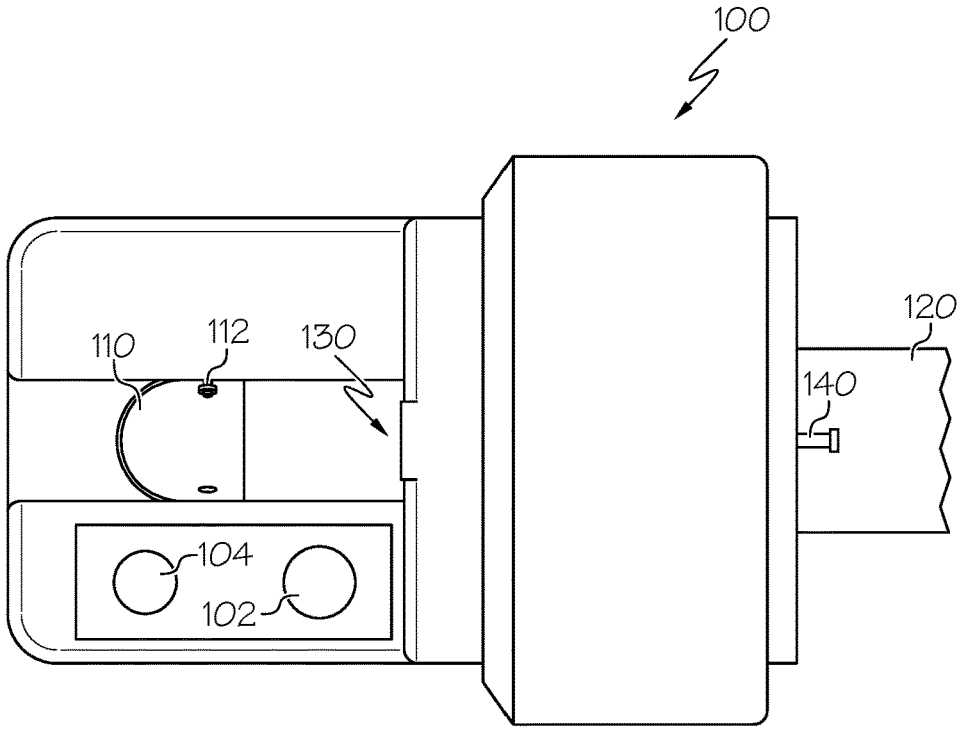

FIG. 2B

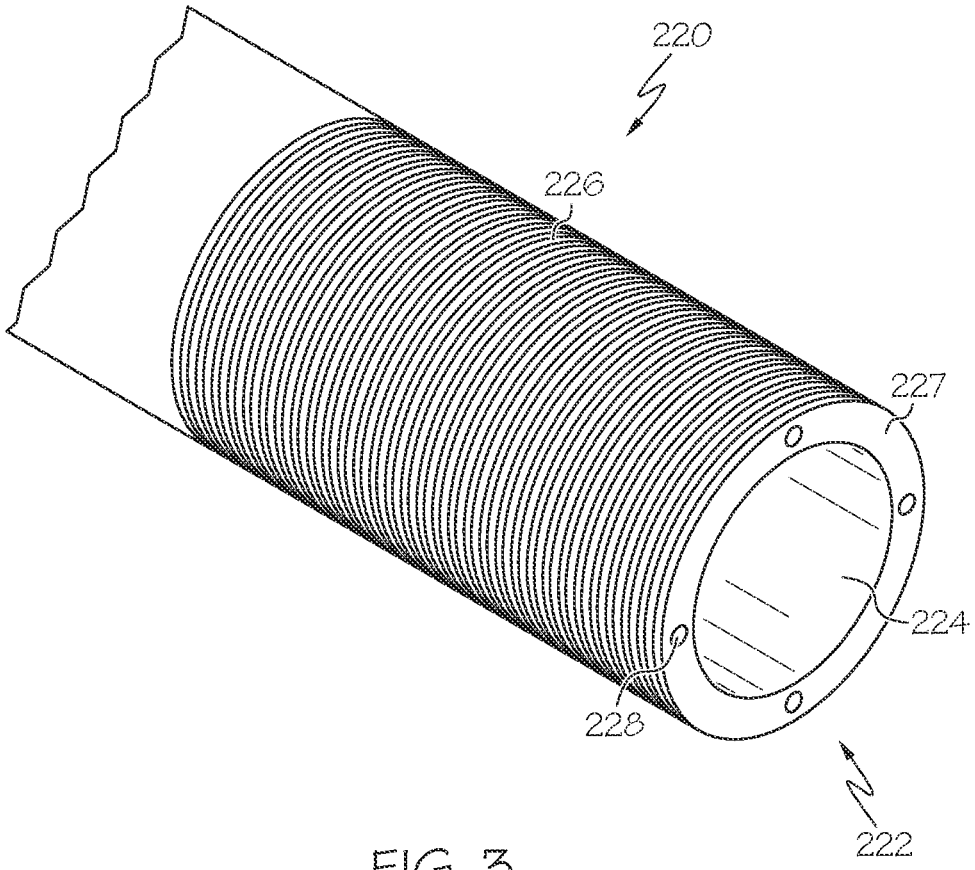

FIG. 3

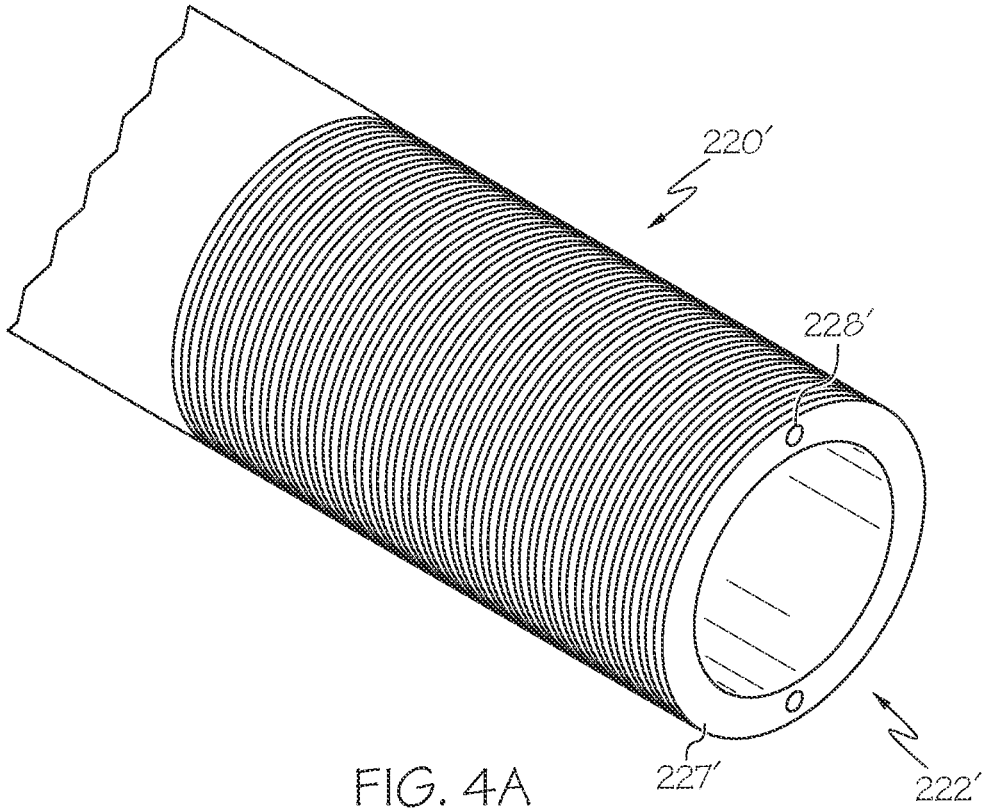

FIG. 4A

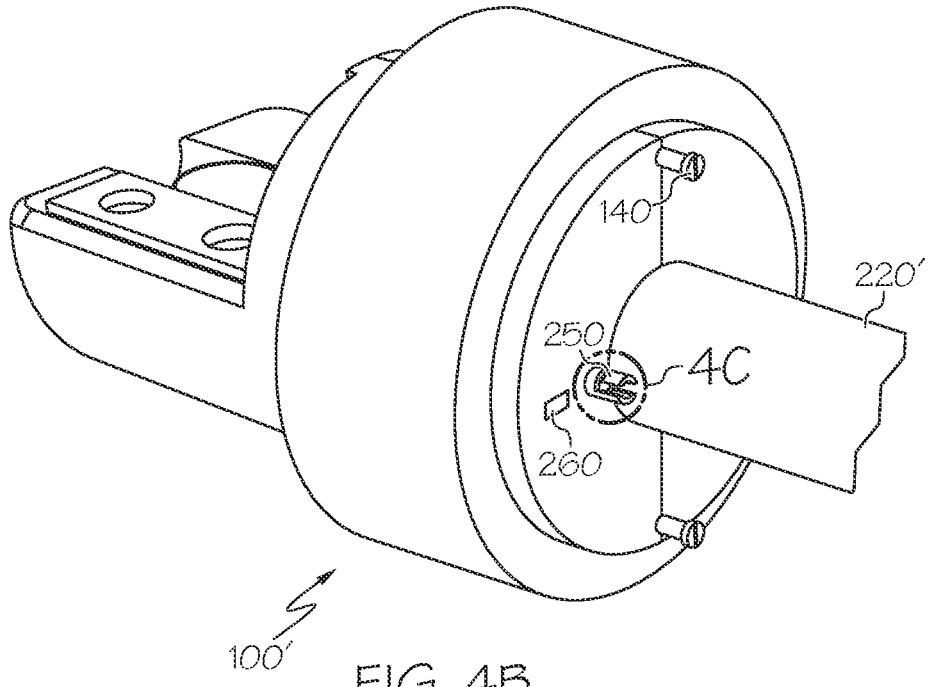

FIG. 4B

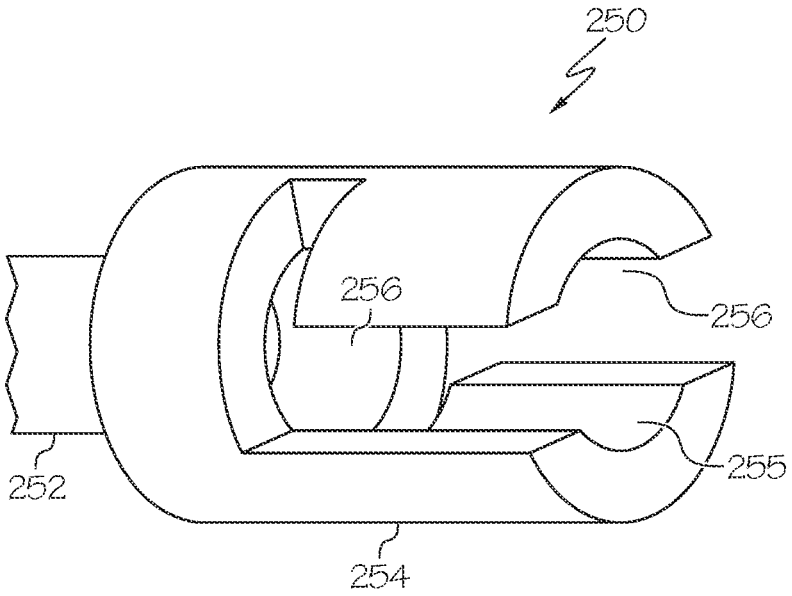

FIG. 4C

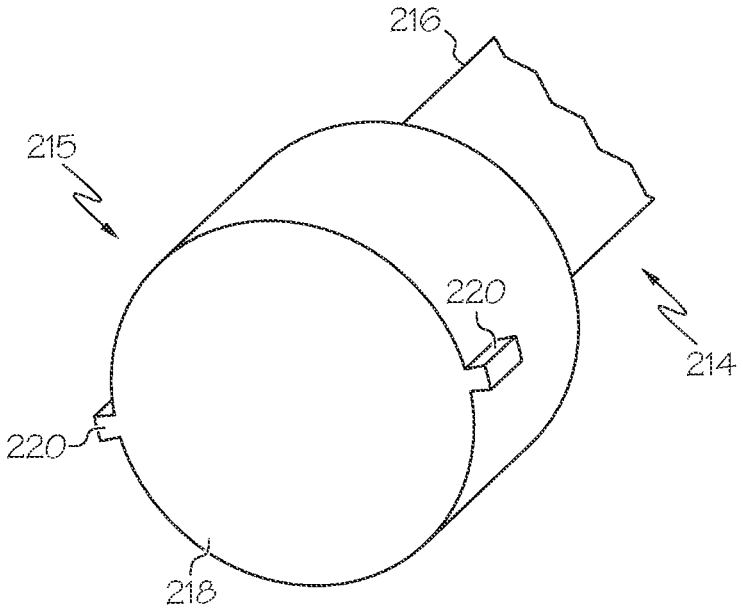

FIG. 4D

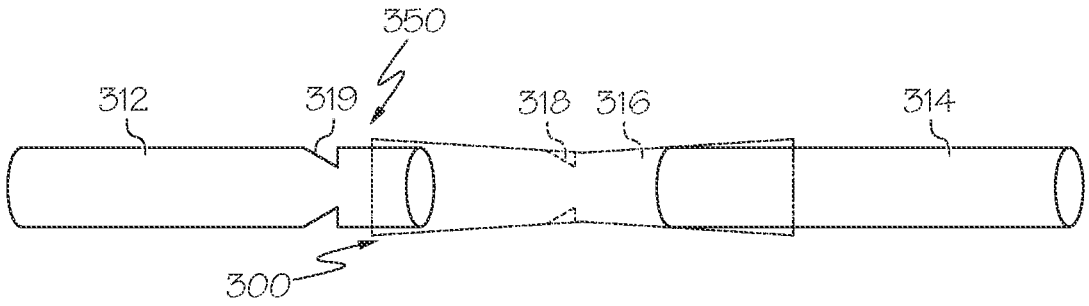

FIG. 5A

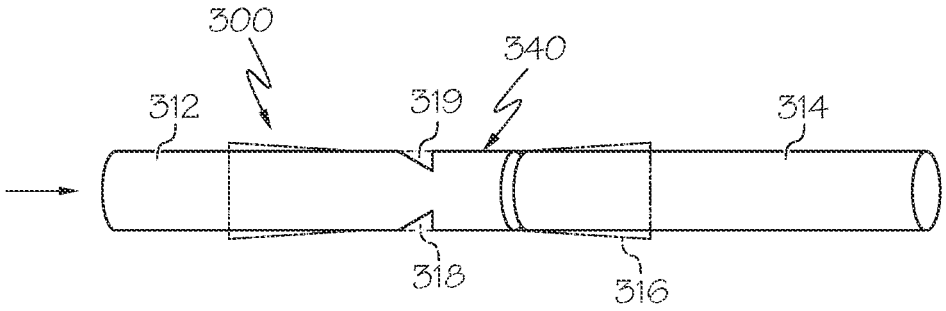

FIG. 5B

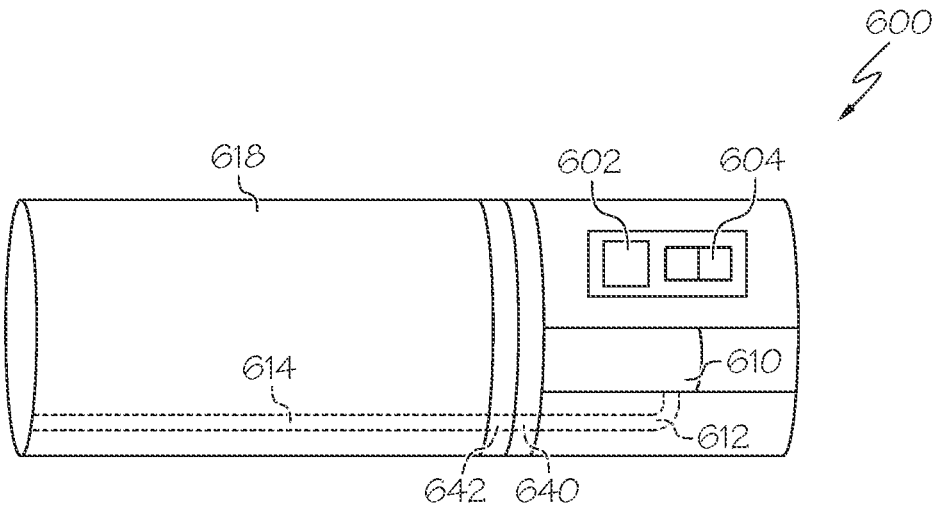

FIG. 5C

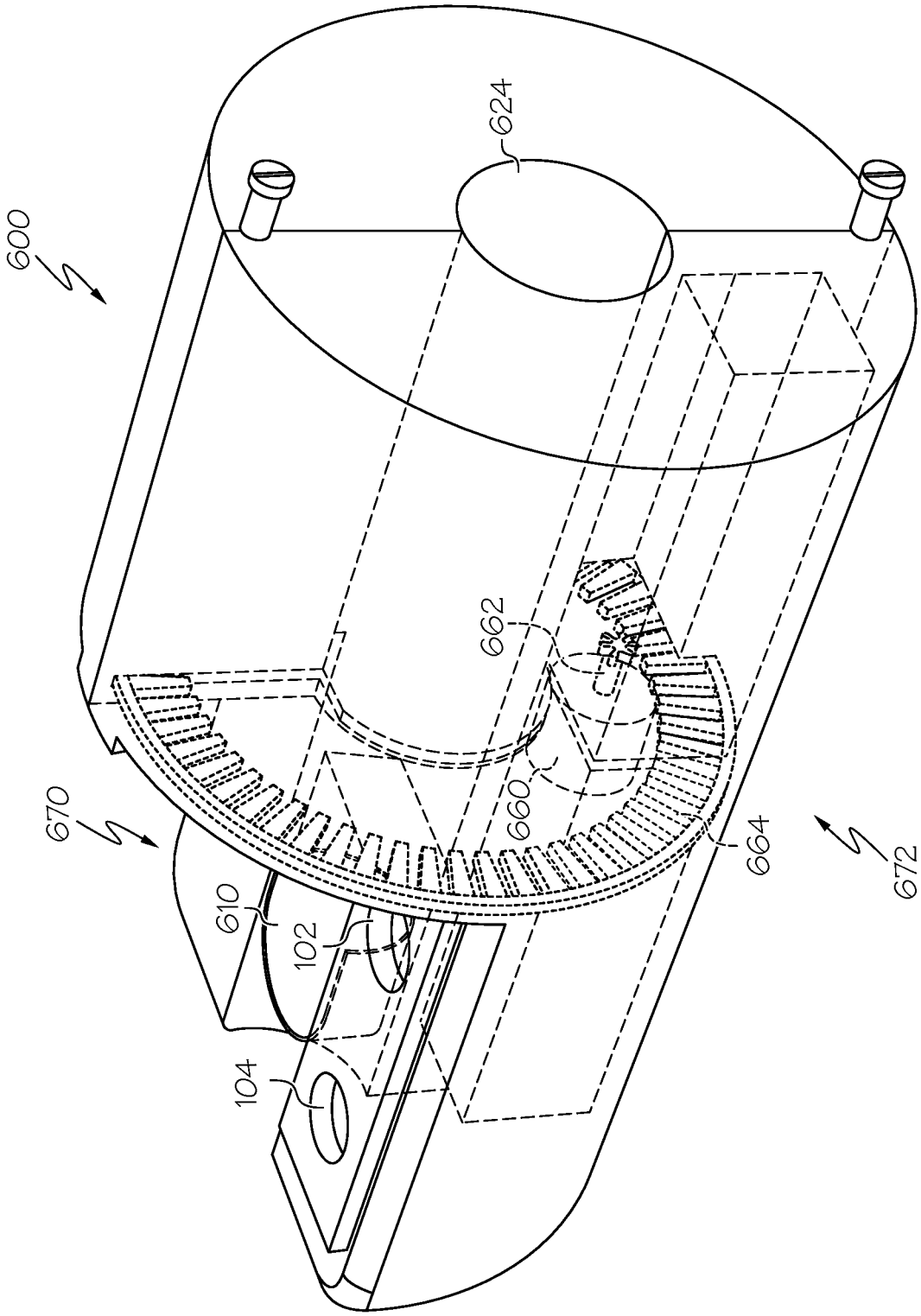

FIG. 6A

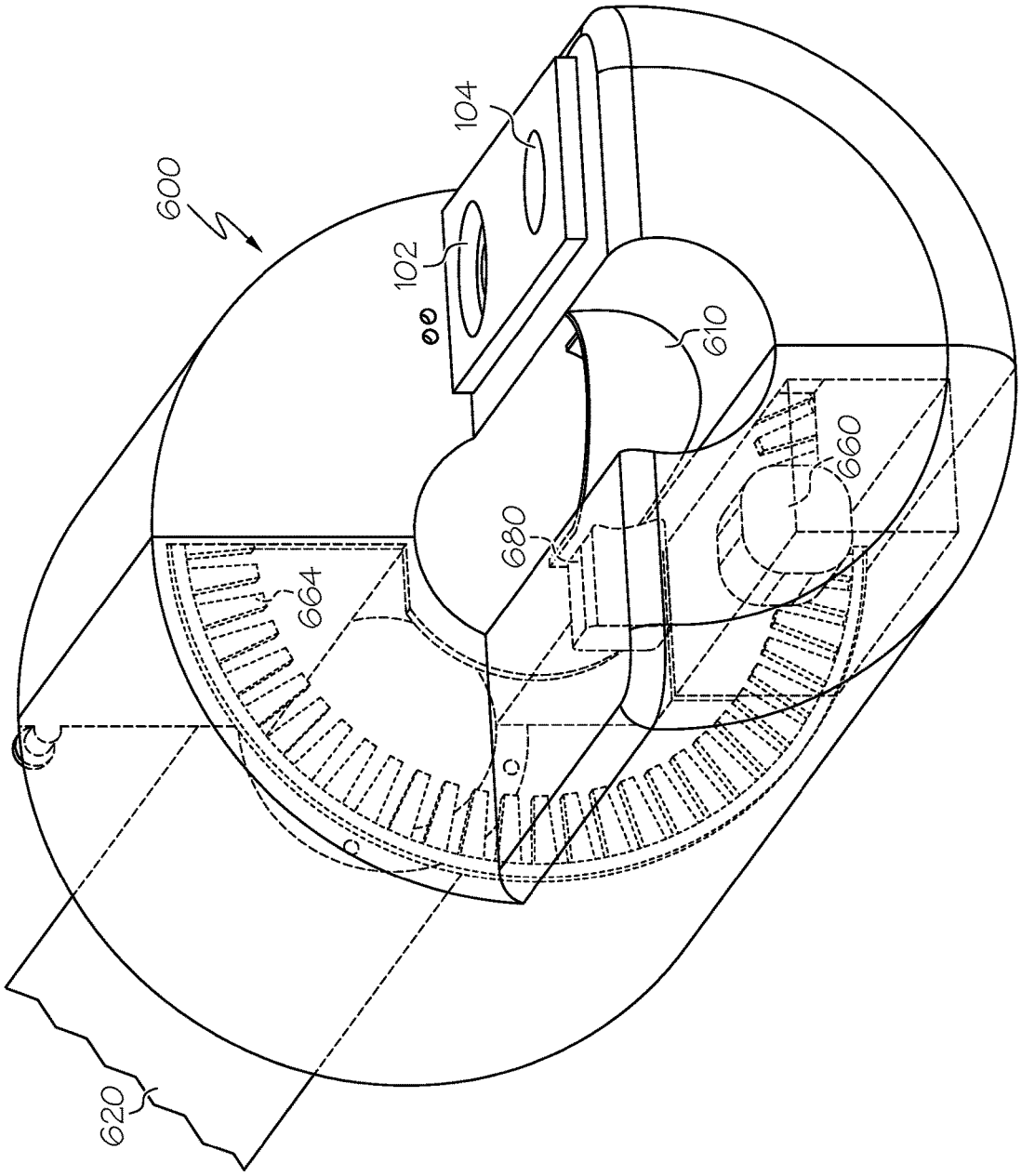

FIG. 6B

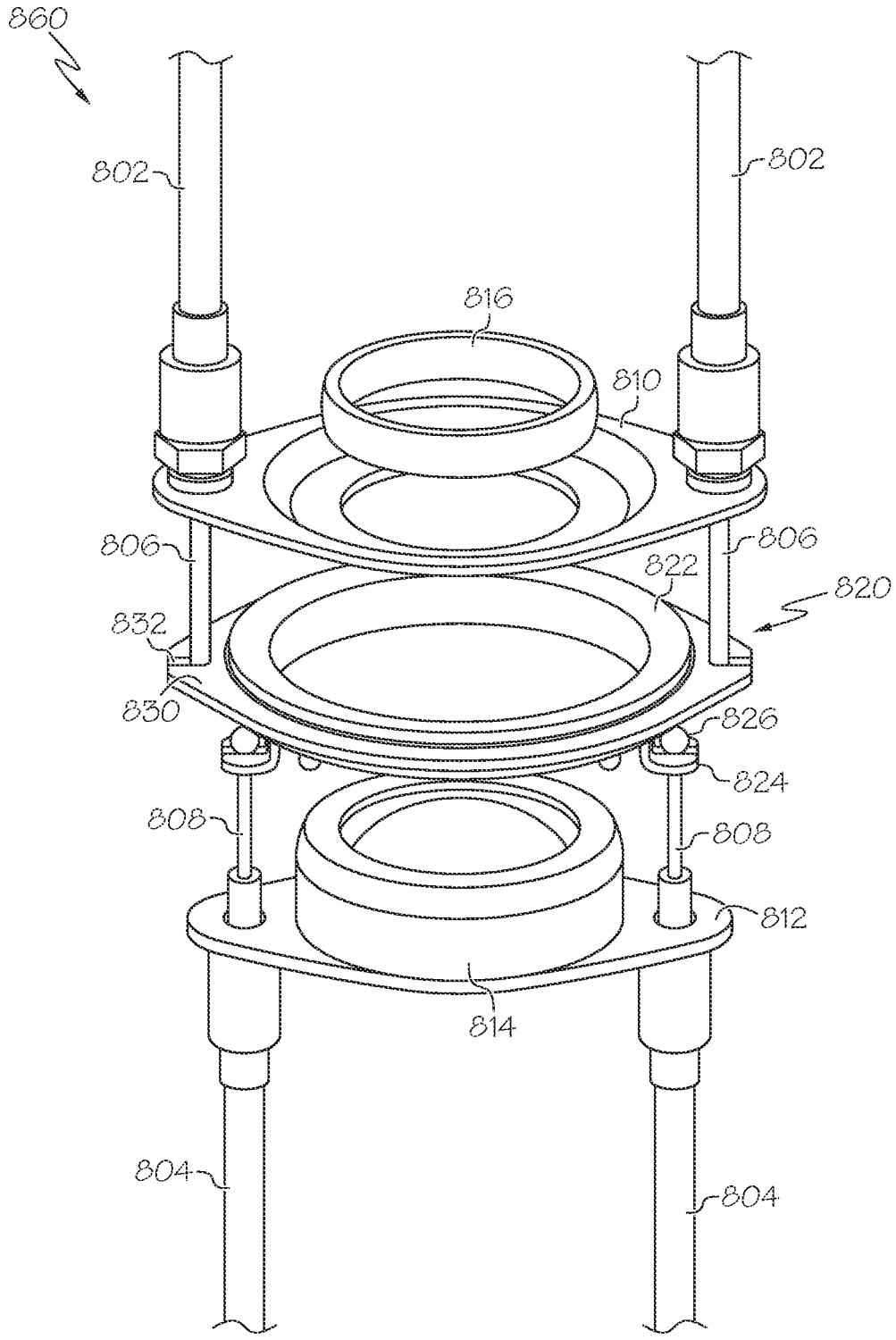
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FIG. 7A

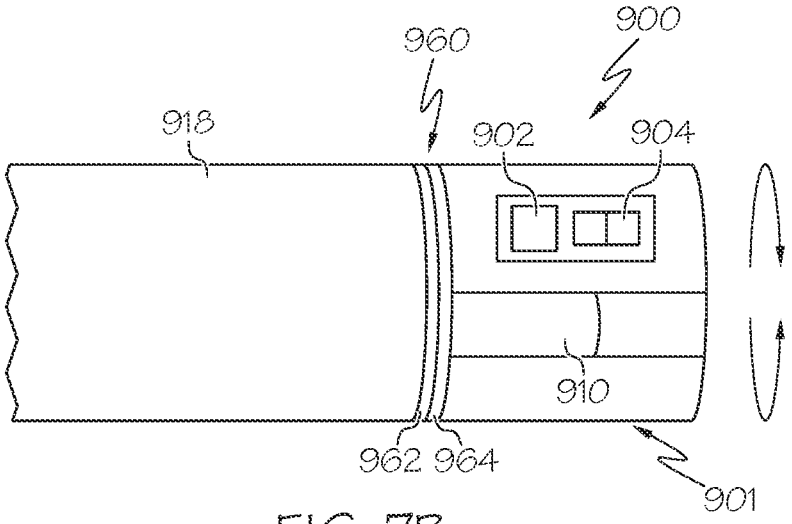
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FIG. 7B

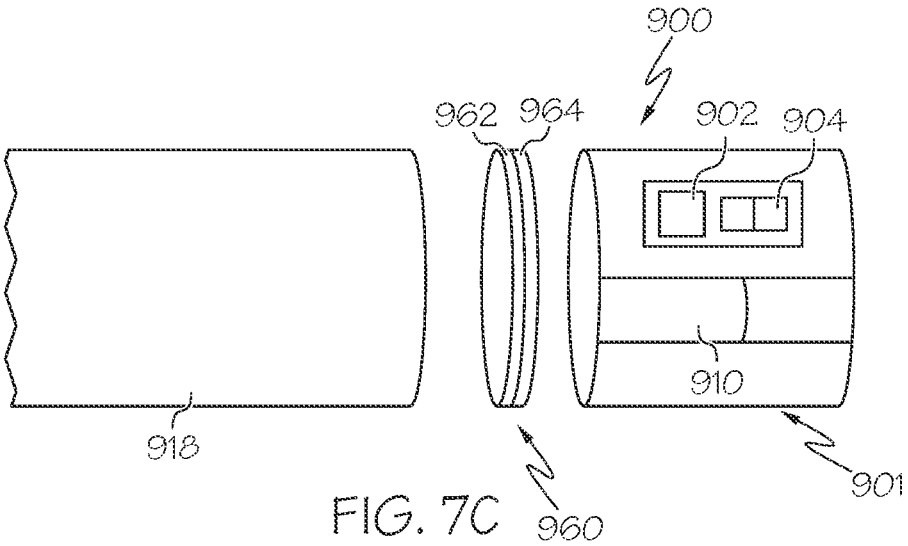
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FIG. 7C

DISTAL TIPS FOR MEDICAL DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

This present disclosure claims priority to U.S. Provisional Patent Application No. 63/008,152, filed on Apr. 10, 2020, the disclosure of which is incorporated herewith by reference.

TECHNICAL FIELD

The disclosure relates generally to elements of medical devices. Aspects of the disclosure pertain to devices, systems, and/or methods for distal tips of endoscopic devices.

BACKGROUND

Duodenoscopes may include a handle portion, which may be gripped by an operator and may include control elements for functions such as steering, suction, water, air, light, and imaging. A duodenoscope may also include a portion which may be inserted into a subject. For example, a duodenoscope may include a shaft suitable for insertion into a subject. Such an insertion portion may include one or more lumens. The lumens of an insertable portion of a duodenoscope may support the functions, for example, conveying air, water, suction, electricity, data, light, and/or images. Tools may also be inserted via a working channel of the shaft. For example, a tool may be inserted by a port in or near the handle of a duodenoscope into the working channel.

A shaft of a duodenoscope may terminate in a steerable distal portion. A distal portion of a duodenoscope may include outlets for air, water, suction, electricity, data, light, images, and/or working tools from lumen(s) of a duodenoscope. Components of the distal tip may be subjected to fluids or other substances of a body lumen of the subject. Before reuse with another patient, the duodenoscope may be subject to reprocessing procedures.

SUMMARY

Examples of the disclosure relate to, among other things, devices, systems, and methods for distal tips of medical devices. Each of the examples disclosed herein may include one or more of the features described in connection with the disclosed examples.

In one example, a medical device may comprise a distal tip having a viewing element, a lighting element, and at least one feature configured to removably couple the distal tip to a shaft. The medical device may also comprise a working channel coupled to the distal tip and defining a central lumen configured to receive a tool. A wall of the working channel may define at least one additional lumen. The working channel may be configured to be removably inserted into the shaft. The medical device may also comprise at least one of a wire, a cable, or a conduit passing through the at least one additional lumen.

Any of the medical devices disclosed herein may have any of the following features. The at least one of the wire, the cable, or the conduit may include the wire or the cable. The wire or the cable may be configured to operate at least one of an elevator of the distal tip, the viewing element, or the lighting element. The distal tip may further include a motor operative to raise or lower the elevator. The at least one of the wire, the cable, or the conduit may include the wire or the cable. The wire or the cable may be configured to provide power to the motor. The wall of the working channel may define at least two additional lumens. The distal tip may have a post extending from a proximal surface thereof. The post may be configured to be detachably connected to a control wire extending through the shaft. The post may define at least one slot, and the control wire may include at least one protrusion configured to be received by the at least one slot. The distal tip may have at least one peg extending from a proximal surface thereof. The peg may be configured to couple the distal tip to the shaft. The distal tip may be configured to be rotatable relative to the shaft. The distal tip may include a motor configured to rotate the distal tip relative to the shaft. The motor may be configured to rotate a gear. The distal tip may include teeth configured to engage with the gear. The distal tip may include a magnet for coupling an element of the distal tip to an element of the shaft. The distal tip may further comprise a distal tip elevator control wire for raising and lowering an elevator of the endoscope. A proximal end of the elevator control wire may include a notch configured to mate with a slot of a shaft elevator control wire. A proximal end of the working channel may include a plurality of threads for securing the proximal end to a handle at a proximal end of the shaft. A proximal end of the distal tip may define a port for operatively connecting an electronic element of the distal tip to a shaft cable or wire extending through the shaft.

In another example, a medical device may comprise: a distal tip having a viewing element, a lighting element, and a nozzle. A working channel may be coupled to the distal tip and define a central lumen configured to receive a tool. A wall of the working channel may define at least one additional lumen. The working channel may be configured to be removably inserted into the shaft. The at least one additional lumen may be configured to be in fluid communication with the nozzle.

Any of the medical devices disclosed herein may have any of the following features. The distal tip may further include a motor operative to raise or lower the elevator. The at least one of the wire, the cable, or the conduit includes the wire or the cable, and wherein the wire or the cable is configured to provide power to the motor.

An example method may comprise: detachably coupling a distal tip to a shaft of a medical device. The distal tip may have: a viewing element, and a lighting element. The method may further comprise feeding a working channel through the shaft and detachably coupling the working channel to a handle of the medical device.

Any of the methods disclosed herein may have any of the following features. The working channel may define a central lumen configured to receive a tool. A wall of the working channel may define at least one additional lumen. At least one of a wire, a cable, or a conduit may pass through at least one additional lumen. The at least one of the wire, the cable, or the conduit may be configured to be operatively connected to at least one of the elevator, the viewing element, the lighting element, or the nozzle.

It may be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed. As used herein, the terms "comprises," "comprising," or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements, but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. The term "exemplary" is used in the sense of "example," rather than "ideal."

The term "distal" refers to a direction away from an operator/toward a treatment site, and the term "proximal" refers to a direction toward an operator. The term "approximately," or like terms (e.g., "substantially"), includes values+/−10% of a stated value.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate examples of the disclosure and together with the description, serve to explain the principles of the disclosure.

FIG. **1** depicts an exemplary duodenoscope.

FIGS. **2**A and **2**B depict an exemplary distal tip for a duodenoscope.

FIG. **3** depicts an exemplary working channel for use with the distal tip of FIGS. **2**A and **2**B.

FIGS. **4**A-**4**D show a distal tip and elements for use therewith.

FIGS. **5**A-**5**C show exemplary securing mechanisms.

FIGS. **6**A-**7**C depict exemplary rotation elements.

DETAILED DESCRIPTION

During reprocessing, it may be difficult to sufficiently clean a distal tip of a duodenoscope and/or a working channel of a duodenoscope. Therefore, it may be desirable for a distal tip of a duodenoscope and/or a working channel be removable from a remainder of the duodenoscope. The distal tip and/or the working channel may be disposable in order to obviate a need to reprocess the distal tip and/or working channel. The distal tip and/or a shaft of the duodenoscope may include features to facilitate connections between elements of the distal tip (e.g., an elevator, air/water nozzle, viewing element, and/or lighting element) and elements in the shaft and handle of the duodenoscope for controlling the elements of the distal tip. The distal tip may also have rotatable elements to allow rotation of the distal tip relative to the shaft of the duodenoscope.

FIG. **1** depicts an exemplary duodenoscope **10** having a handle **12** and an insertion portion **14**. Duodenoscope **10** may also include an umbilicus **16** for purposes of connecting duodenoscope **10** to sources of, for example, air, water, suction, power, etc., as well as to image processing and/or viewing equipment. Although the term duodenoscope may be used herein, it will be appreciated that other devices, including, but not limited to, endoscopes, colonoscopes, ureteroscopes, bronchoscopes, laparoscopes, sheaths, catheters, or any other suitable delivery device or medical device may be used in connection with the coupling devices and methods of this disclosure. Although side-facing devices are particularly discussed, the embodiments described herein may also be used with front-facing endoscopes (e.g., endoscopes where a viewing element faces longitudinally forward).

Insertion portion **14** may include a sheath or shaft **18** and a distal tip **20**. Distal tip **20** may include an imaging device (e.g., a camera) **22** and a lighting source **24** (e.g., an LED or an optical fiber). Distal tip **20** may also include an elevator **26** for changing an orientation of a tool inserted in a working channel of the duodenoscope **10** (further details about insertion of a tool are provided below). Elevator **26** may be pivotable via, e.g., an actuation wire. Distal tip **20** may be side-facing. That is, imaging device **22** and lighting source **24** may face radially outward, perpendicularly or approximately perpendicularly to a longitudinal axis of shaft **18** and distal tip **20**.

A distal portion of shaft **18** that is connected to distal tip **20** may have a steerable section **28**. Steerable section **28** may be, for example, an articulation joint. Shaft **18** and steerable section **28** may include a variety of structures which are known or may become known in the art. Example features of distal tip **20** are described in further detail with respect to FIGS. **2**A-**7**C, herein.

Handle **12** may have one or more control mechanisms **30**. Control mechanisms **30** may provide control over steerable section **28** or may allow for provision of air, water, suction, etc. For example, handle **12** may include control knobs **32**, **34** for left, right, up, and/or down control of steerable section **28**. For example, one of knobs **32**, **34** may provide left/right control of steerable section **28**, and the other of knobs **32**, **34** may provide up/down control of steerable section **28**. Handle **12** may further include one or more locking mechanisms **36** (e.g., knobs or levers) for preventing steering of steerable section **28** in at least one of an up, down, left, or right direction. Handle **12** may include an elevator control lever **38**. Elevator control lever **38** may raise and/or lower elevator **20**. A port **40** may allow passage of a tool through port **40**, into a working channel of the duodenoscope **10**, through sheath **18**, to distal tip **20**.

In use, an operator may insert at least a portion of shaft **18** into a body lumen of a subject. Distal tip **20** may be navigated to a procedure site in the body lumen. The operator may insert a tool (not shown) into port **40**, and pass the tool through shaft **18** via a working channel to distal tip **20**. The tool may exit the working channel at distal tip **20**. The user may use elevator control lever **38** to raise elevator **26** and angle the tool toward a desired location (e.g., a papilla of the pancreatico-biliary tract). The user may use the tool to perform a medical procedure.

FIGS. **2**A and **2**B provide different views of an exemplary distal tip **100**. FIG. **2**A provides a perspective view, while FIG. **2**B provides a profile view. Distal tip **100** may be used in place of distal tip **20** of duodenoscope **10**, and may have any of the properties of distal tip **20**. Distal tip **100** may be disposable. Distal tip **100** may be positioned on shaft **18** prior to use of duodenoscope **10** and removed from shaft **18** after use. Distal tip **100** may be disposed, and other portions of duodenoscope **10** may be reprocessed.

Distal tip **100** may include features including the following: viewing element **102** (e.g., a camera), lighting source **104**, air and/or water nozzle(s), and/or elevator **110**. Elevator **110** may have any of the properties of elevator **20**. Elevator **110** may include an attachment point **112** for connecting elevator **110** to a mechanism for raising and/or lowering elevator **110** (e.g., a wire or a motorized element, as described below). Viewing element **102** may have any of the properties of viewing element **22**. Viewing element **102** may include, for example, a charge coupled device ("CCD") unit, an image sensor, and/or an objective lens. Lighting source **104** may have any of the properties of lighting source **24**. Lighting source **104** may include, for example, LED(s) or optical fiber(s). Distal tip **100** may also include internal components such as a motor and/or gears for rotation of distal tip **100** (see FIGS. **6**A-**7**C, described below). Distal tip **100** may also house a motor for raising and lowering elevator **110**, as described further with respect to FIGS. **6**A-**6**B.

A working channel **120** may extend from a proximal end of distal tip **100**. Working channel **120** may define a lumen (e.g., a central lumen) for receiving tools, delivering suction, and/or receiving body fluids or tissues. Working channel **120** may be detachable from distal tip **100** or may be fixedly coupled to distal tip **100**. Working channel **120** may extend

proximally from distal tip **100** to handle **12**. When distal tip **100** is attached to a distal end of the duodenoscope, working channel **120** may be backfed through shaft **18**, to handle **12**. In handle **12**, working channel **120** may be affixed to an appropriate structure (e.g., among others, instrument port **40**). As discussed below, walls of working channel **120** may house a variety of components, such as wires and/or cables for viewing elements **102**, lighting elements **104**, and/or motors for rotation of distal tip **100** or operation of elevator **110**. Working channel **120** may also house conduits in fluid communication with the air and/or water nozzles and/or a control mechanism (e.g., a wire) for elevator **110**.

Distal tip **100** may house complementary components that are either one piece with the components of working channel **120** (e.g., in the case of a working channel **120** fixedly attached to distal tip **100**) or that are separate components that are operatively connected/connectable to the components of working channel **120**. Wires and/or cables, conduits, and elevator control elements may exist in each of handle **12**, shaft **18**, and distal tip **100** and may include single, unitary pieces or pieces that are operatively coupled to one another.

A lumen may extend through working channel **120**, and the lumen may allow instruments, suction, and/or body tissue to be passed therethrough. Working channel **120** may terminate at a proximal end of distal tip **100** or within distal tip **100**. The lumen of working channel **120** may be in communication with an opening **130** of the distal tip. The lumen of working channel **120** may terminate at opening **130**, or structures of distal tip **100** (e.g., walls of distal tip **100**) may form a channel in communication with the lumen of working channel **120**. An instrument may be passed through the lumen of the working channel **120** and out of opening **130**. Elevator **110** may be activated by elevator control lever **28** in order to raise or lower in order to change an orientation of the instrument extending out of opening **130**.

A proximal side of distal tip **110** may include one or more mating components **140**. As shown in FIG. **2**A, distal tip **110** may have two mating components **140**. Mating components **140** may include a variety of structures, such as those described below with respect to FIGS. **4**A-**4**C. As shown in FIG. **2**A, mating component **140** may include a protrusion (e.g., a peg) extending proximally from a proximal surface of distal tip **100**. Mating component **140** may include a post and a head. Mating component **140** may have, for example, a shape like a head of a screw. Mating component **140** may mate with a component of shaft **18** of the duodenoscope or otherwise secure distal tip **100** to shaft **18**. For example, a distal face of shaft **18** may include curved slots (not shown) for receiving mating components **140**. Rotation of distal tip **100** relative to shaft **18** may cause mating components **140** to engage with the slots and to secure distal tip **100** to shaft **18**. Alternatively, a distal face of shaft **18** may include openings that have round or other shapes for receiving and engaging with components **140** in order to secure distal tip **100** to shaft **18**. Further details regarding example mating mechanisms will be provided below.

FIG. **3** shows aspects of an exemplary working channel **220**, which may have any of the properties of working channel **120** and may be used in conjunction with a distal tip, such as distal tip **100**. Alternatively, working channel **220** may be used with alternative duodenoscopes. FIG. **2**A shows a working channel **220**, terminating in a proximal end **222**. Lumen **224** may extend through a length of working channel **220**, from proximal end **222** to a distal end of the working channel. Lumen **224** may be used to pass instruments from a port in a handle of a duodenoscope, through opening **130** in distal tip **110**. Body fluids may also pass proximally through lumen **224** via opening **130**.

Proximal end **222** of working channel **220** may include mating structure **226** that facilitates mating of working channel **220** with handle **12**. For example, as shown in FIG. **3**, mating structure **226** may include threads to provide for a screw fit between working channel **220** and a receptacle in the handle, which may be in communication with port **40**.

A wall **227** of working channel **220** may define one or more lumens **228** that extend longitudinally through wall **227**. Lumens **228** may be defined by a circular surface. Alternatively, lumens **228** may have alternate shapes. For example, lumen **228** may include a slot that extends radially inward from an outer surface of working channel **220**. Lumen **228** may be entirely enclosed or may include portions that are open to an outer surface of working channel **220**.

Lumens **228** may be in addition to a central lumen for receiving/transmitting tools, suction, and body fluids/tissue. Lumens **228** may extend along a longitudinal axis of working channel **220** but may not be coaxial with a central longitudinal axis of working channel **220**. Lumens **228** may surround the central lumen. Each of lumens **228** may extend from proximal end **222** to a distal end of working channel **220**. Lumens **228** may be open at proximal end **222** and at the distal end of working channel **220**. Wall **227** may define any suitable number of lumens **228**. For example, as shown in FIG. **2**, wall **227** may define four lumens **228**. Lumens **228** may form passageways for wires and/or cables, conduits, and/or elevator control elements that extend from the handle, through shaft **18**, and to distal tip **110** of the duodenoscope. For example, cables and/or wires for powering and/or controlling viewing element **102** and lighting element **104** and/or for receiving signals from viewing element **102**. Water and/or air supplies may also pass through lumens **228**. Conduits may pass through lumens **228** in order to supply water and/or air from the handle to the distal tip of the duodenoscope. Alternatively, water and/or air may travel directly through lumens **228** without an intermediate conduit structure passing through lumens **228**.

By way of example, working channel **220** may include four lumens **228**. A first of the four lumens **228** may be used for providing air or another fluid, and a second may be used for providing water or another fluid. A third lumen **228** may be used to carry a signal cable for a feed from viewing element **102**. A fourth lumen **228** may be used to carry a power cable, which may power, e.g., viewing element **102**, lighting element **104**, and motors of distal tip **100** used to raise and lower elevator **110** and/or to rotate distal tip **100**.

A receptacle in handle **12** may provide for automatic connections between elements passing through lumens **228** of working channel **220** and corresponding structures in handle **12**. For example, screwing in working channel **220** into an appropriate receptacle may provide for electrical connection between controls in handle **12** and corresponding wires in lumens **228**. In such an example, after backfeeding working channel **220** through shaft **18**, proximal end **222** of working channel **220** may be seated in a receptacle of handle **12**, providing a single step for forming connections between elements in lumens **228** with corresponding elements of handle **12**. Alternatively, elements carried in lumens **228** may be separately connected to corresponding elements of handle **12** before or after proximal end **222** is secured to handle **12**. For example, wiring carried in a lumen **228** may terminate proximally in a plug that may be inserted into a receptacle of handle **12**.

FIGS. **4**A and **4**B show an alternative distal tip **100'** and an alternative working channel **220'**. While distal tip **100'** and working channel **220'** are described together herein, features of distal tip **100'** and/or working channel **220'** may be combined with other aspects described herein. For example, features of distal tip **100** may be used alongside features of working channel **220'**, and features of distal tip **100'** may be used alongside features of working channel **220**. Distal tip **100'** and working channel **220'** may have any of the features of distal tip **100** and working channel **220**, respectively, except where specified.

As compared to working channel **220**, working channel **220'** may have fewer lumens **228'** formed therein. Instead of passing through lumens **228'**, some components may pass outside of working channel **220'**. For example, working channel **220'** may define two lumens **228'**. The two lumens **228'** may carry air (or another fluid) and water (or another fluid), respectively. Cables or wires for providing power and/or receiving an image signal from viewing element **102** may pass externally of working channel **220**, through shaft **18**. The cables or wires may extend through a port **260** on a proximal face of distal end **100'**. Port **260** may be an opening, through which cables and/or wires may extend proximally from electronic elements (e.g., motors, viewing element **102**, and/or lighting element **104**). When distal tip **100'** is positioned on shaft **18**, the cable(s) and/or wire(s) may be backfed through shaft **18** and connected to a portion of handle **12**. In such an example, port **260** may include sealing elements which prevent fluids (such as bodily fluids) from passing through port **260**. Alternatively, port **260** may form a receptacle for receiving a connector. For example, single-use or reusable wire(s) and/or cable(s) may extend distally from handle **12** toward distal tip **110'**. The wire(s) and/or cable(s) may be fixedly or removably coupled to elements of handle **12**. The wire(s) and/or cable(s) may terminate distally in a connector which may be inserted into port **260** in order to form electrical connections with elements of distal tip **100'**.

As described above with respect to distal tip **100**, elevator **110** may be operated (raised or lowered) via a motor in distal tip **100**. Alternatively, a control wire **214** (FIG. **4**D) may be connected to elevator control lever **38** and may pass through shaft **18**. Movement of elevator control lever **38** may cause proximal and distal motion of control wire **214**. Control wire **214** may terminate in a distal end **215**, shown in FIG. **4**D. Distal end **215** may include a shaft **216** and a head **218**. Head **218** may extend radially outward relative to shaft **216**. One or more protrusions **220** may extend radially outward from a surface of head **218**. For example, as shown in FIG. **4**D, two protrusions **220** may extend from head **218**. Protrusions **220** may have any suitable shape. For example, as shown in FIG. **4**D, protrusions **220** may have a greater longitudinal dimension than a circumferential dimension (may extend further longitudinally along head **218** than circumferentially about head **218**).

Control wire **214** may be operatively connected to a pin **250** extending proximally from a proximal face of distal tip **100'**. Pin **250** may form a proximal end of a control wire extending within distal tip **100'**, which may be operatively connected to elevator **110**, such that when pin **250** is moved proximally, elevator **110** raises, and when pin **250** is moved distally, elevator **110** lowers. Alternatively, pin **250** may be operatively connected to a separate control wire within elevator **110** such that the elevator raises and lowers as pin **250** is moved proximally and distally. FIG. **4**C shows a detailed view of pin **250**. Pin **250** may include a shaft **252** and a head **254** having a greater radial dimension than shaft **252**. Alternatively, pin **250** may have a uniform radial dimension. Head **254** may define a cavity **255**, which may be open on a proximal end of head **254**. A portion of pin **250** (e.g., head **254**) may define one or more slots **256**. For example, as shown in FIG. **4**C, pin **250** may define two slots **256** that extend through a wall of head **254**. Slots **256** may be L-shaped. A distal portion of slot **256** may extend in a circumferential direction, while a proximal portion of slot **256** may extend in a longitudinal direction.

In order to operatively connect control wire **214** to pin **250**, distal end **215**, including head **218**, may be inserted into cavity **255** with protrusions **220** aligned with slots **256**. Distal end **215** may be moved distally so that protrusions **220** track along slots **256**. Distal end **215** may then be rotated so that protrusions **220** continue to track along the portion of slot **256** that extends circumferentially about pin **250**.

Control wire **214** may be coupled to pin **250** while pegs **140** are simultaneously (or subsequently or previously) coupled to features of shaft **18**. For example, as distal tip **100'** and shaft **18** are brought together, distal end **215** of control wire **214** may be inserted into cavity **255** of pin **250**, and pegs **140** may be inserted into holes, slots, or other features of shaft **18**. Distal tip **100'** may then be twisted with respect to shaft **18**. Twisting may cause control wire **214** and pin **250** to be coupled together, while coupling pegs **140** to shaft **18** to secure distal tip **100'** with respect to shaft **18**. Distal tip **100** or **100'** may also be attached to shaft **18** via twisting, even if pin **250** is not present on distal tip **100'**. A skirt may be positioned about distal tip **100**/**100'** and shaft **18**, in order to further secure distal tip **100**/**100'** to shaft **18** and to inhibit fluid ingress and egress between distal tip **100**/**100'** and shaft **18**. After a procedure, a distal tip **100** or **100'** may be detached from shaft **18** (e.g., via twisting in the opposite direction). Distal tip **100** or **100'** may be disposable or may be reprocessed for a further procedure.

Although light emitting diodes have been discussed with respect to distal tips **100**, **100'**, it will be appreciated that optical fibers may be used alternatively or additionally. Optical fibers may extend through shaft **18** and distal tip **100** or **100'**. The optical fibers of shaft **18** and distal tip **100** or **100'** may meet at a junction between shaft **18** and distal tip **100** or **100'**. The optical fibers may be flush with a proximal surface of distal tip **100** or **100'** and a distal surface of shaft **18**. Flushness of the optical fibers may result in easier cleaning of components such as shaft **18**, because fluids may not leak into crevices or adhere to outer surfaces of the optical fibers.

FIGS. **5**A-**5**C show alternative attachment mechanisms for coupling a portion of a control wire in shaft **18** to a portion of a control wire in a distal tip, such as distal tip **100** or **100'**. Although the attachment mechanisms described in FIGS. **5**A-**5**C may be described with respect to control wires for raising and lowering an elevator, it will be appreciated that the attachment mechanisms may additionally or alternatively be used to fix a distal tip (such as distal tip **100** or **100'**) to shaft **18**.

FIGS. **5**A-**5**B show a fixation mechanism **300**, which may function like a finger trap. A distal tip control wire **312** may connect to an elevator (e.g., elevator **110**) and may extend proximally through a distal tip toward shaft **18**. A shaft control wire **314**, which may extend through shaft **18**, may have a sleeve **316** fixed thereabout. Sleeve **316** may define a lumen and may extend circumferentially around a distal portion of shaft control wire **314**, which may be disposed within the lumen.

One or more protrusions **318** may extend radially inwardly from an inner surface of sleeve **316**. One or more

notches **319** may be formed in distal tip control wire **312**. A single protrusion **318** may extend around an inner circumference of sleeve **316**, and a single notch **319** may extend around a circumference of distal tip control wire **312**. Alternatively, there may be multiple, discrete protrusions on sleeve **316** and multiple, discrete notches on distal tip control wire **312**.

Protrusion **318** and notch **319** may have the same or complementary shapes, such that protrusion **318** may engage notch **319** in order to retain distal tip control wire **312** within sleeve **316** when distal tip control wire **312** is inserted into sleeve **316**, and protrusion **318** is aligned with notch **319**. For example, proximal sides of protrusion **318** and notch **319** may be approximately perpendicular to a longitudinal axis of shaft control wire **314**, sleeve **316**, and/or distal tip control wire **312**. Distal sides of protrusion **318** and notch **319** may be angled radially outward/tapered toward the first side. Protrusion **318** and notch **319** may have triangular or wedge shapes.

FIG. **5**A shows distal tip control wire **312** and shaft control wire **314**, before distal tip control wire **312** is fully inserted into sleeve **316**. In order to couple distal tip control wire **312** to shaft control wire **314**, a proximal end of distal tip control wire **312** may be inserted into sleeve **316**. Distal tip control wire **312** may be moved proximally. Distal tip control wire **312** may contact and deflect protrusions **318** radially outward. Sleeve **316** and/or protrusion **318** may be formed of material that is resilient, flexible, and/or has shape memory properties and is capable of flexion to allow a proximal end of distal tip control wire **312** to pass protrusion **318**. As shown in FIG. **5**B, protrusion **318** may engage notch **319** to retain distal tip control wire **312** within sleeve **316**. Pulling distal tip control wire **312** distally with sufficient force may cause distal tip control wire **312** to disengage with sleeve **316** without destroying sleeve **316**.

Although sleeve **316** has been described as being fixed around shaft control wire **314**, sleeve **316** may alternatively be fixed around distal tip control wire **312**, and shaft control wire **314** may include one or more notches, similar to notches **319**. Although protrusions **318** have been described as extending radially inward from sleeve **316**, it will be appreciated that protrusions **318** could extend radially outward from distal tip control wire **312** (or shaft control wire **314**). Notches (similar to notches **319**) could be formed in a wall of sleeve **316**.

FIG. **5**C shows an alternative mechanism for attaching a shaft **618** (having any of the properties of shaft **18**) to a distal tip **600** (having any of the properties of distal tips **100**, **100'**). Distal tip **600** may include a viewing element **602** (which may have any of the properties of viewing element **102**) and a lighting source **604** (having any of the properties of lighting source **104**). Distal tip **600** may also include an elevator **610**, which may have any of the properties of elevator **110**. A shaft control wire **614** may extend through a length of shaft **618** and may have any of the properties of shaft control wire **314**. Shaft control wire **614** may be operatively connected to an actuator in a duodenoscope handle (such as handle **12**) in order to move shaft control wire **614** proximally and distally. A distal tip control wire **612** may extend longitudinally through distal tip **600** and may be operatively connected to elevator **110**, such that proximal and distal movement of distal tip control wire **612** may raise and/or lower elevator **110**.

Distal tip control wire **612** may terminate proximally in a magnetic element **640**. Magnetic element **640** may be formed of the same material as a remainder of distal tip control wire **612** or may be a separate piece from distal tip control wire **612** that is fixedly secured to distal tip control wire **612**. Shaft control wire **614** may terminate distally in a magnetic element **642**. Magnetic element **642** may be formed of the same material as a remainder of shaft control wire **614** or may be a separate piece from shaft wire **614** that is fixedly secured to shaft control wire **614**. Portions of magnetic elements **640** and **642** that face one another may have opposite polarities, such that magnetic elements **640** and **642** are attracted to one another. A magnetic force between magnetic elements **640** and **642** may be calibrated so that magnetic elements **640** and **642** secure distal tip control wire **612** to shaft control wire **614**. After use, a sufficient force by a user may be used to separate magnetic element **640** from magnetic element **642**. Alternatively, at least one of magnetic elements **640** and **642** may be electromagnetic and capable of being turned off to release magnetic element **640** from magnetic element **642**. Alternatively, a key or other device may be configured to release magnetic elements **640** and **642** following use.

FIGS. **6**A and **6**B depict transparent views of an exemplary distal tip **600**, which may have any of the features of the distal tips described above. Distal tip **600** may define a lumen **624** passing longitudinally therethrough. Lumen **624** may lead from a proximal opening on a proximal face of distal tip **600** to a distal opening. The distal opening of lumen **624** may lead to an elevator **610**. Elevator **610** may have any of the features of the elevators described above. Elevator **610** may be configured to raise and lower in order to change an orientation of an instrument passing through lumen **624** and out of a distal end of lumen **624**. As shown in FIG. **6**B, a working channel **620** may be received within lumen **624**. Working channel **620** may have any of the properties of working channels **120**, **220**, **220'**, described above. For example, working channel **620** may have the properties of working channel **220**.

Distal tip **600** may include a rotation motor **660**. Rotation motor **660** may be powered by, for example, a built in power source (e.g., a lithium ion battery), a wire or cable passing through a lumen of working channel **620**, as described above, with respect to working channel **220**. Rotation motor **660** may power a gear **662**. Rotation motor **660** may cause gear **662** to rotate in a first direction or in a second direction. Gear **662** may have teeth formed around at least a portion of a circumference of gear **662**.

Gear **662** may engage with teeth **664**, which may extend radially inward from an inner circumferential surface of distal tip **600**. Teeth **664** may function similarly to a rack gear but may be curved to correspond to a circumference of distal tip **600**. As gear **662** rotates, gear **662** may engage with teeth **664** to cause rotation of a rotatable portion **670** of distal tip **600** relative to a stationary portion **672** of distal tip **600**. Rotatable portion **670** may be distal to stationary portion **672**. As shown, rotation motor **660** and gear **662** may be disposed in rotatable portion **670**, and teeth **664** may be stationary (non-rotating), such that operation of rotation motor **660** causes rotatable portion **670**, along with rotation motor **660**, to rotate abut a longitudinal axis of distal tip **600** and/or lumen **624** (since teeth **664** are radially arranged about that axis). Alternatively, rotation motor **660** and gear **662** may be disposed in stationary portion **672**, and teeth **664** may be disposed in rotatable portion **670**, such that rotation of teeth **664** causes rotation of rotatable portion **670**.

Teeth **664** may extend around an entirety of a circumference of distal tip **600**, to allow approximately 360-degree rotation of rotatable portion **670**. Alternatively, as shown, teeth **664** may extend around only a portion of a circumference of distal end **600**, to allow less than 360-degree rotation

(e.g., approximately 90 degree, approximately 180 degree, or approximately 270 degree rotation). Stops may be disposed at ends of rotation (e.g., on an inner circumference of distal tip **600**) to limit rotation to the amounts described above. Rotatable portion **670** may be coupled to stationary portion **672** via, e.g., a bearing unit such as a polymer bearing unit.

Distal tip **600** may also include an elevator motor **680** (see FIG. **6**B). Elevator motor **680** may cause raising and lowering motion of elevator **610**. Elevator motor may be powered by a wire, cord, or a cable, which may extend through a lumen of working channel **620** (e.g., as described with respect to working channel **220**).

Although rotation motor **660**, gear **662**, teeth **664**, and elevator motor **680** are described with particular respect to disposable distal tips, such as those described above, it will be appreciated that those elements may be used with a variety of distal tips of duodenoscopes or other types of endoscopes.

FIGS. **7**A and **7**B depict components that may be used to facilitate rotation of a distal tip of duodenoscope **10** relative to shaft **18** of duodenoscope **10**. The components of FIGS. **7**A and **7**B may be used along with the distal tips described herein or with alternative distal tips.

FIG. **7**A depicts a detangler **860**, that may be used to assist in inhibiting twisting and tangling of components such as wires or cables extending between a rotating portion (e.g., a distal tip) of a duodenoscope or other endoscope and a non-rotating portion (e.g., a shaft) of the duodenoscope or other endoscope.

For example, cables **804** may extend through a shaft, such as shaft **18**. Cables **804** may extend through or be fixed to a plate **812**. Alternatively, plate **812** may be omitted. Plate **812** may be a portion of a distal end of the shaft (e.g., a distal face of the shaft). Distal portions **808** of cables **804** may extend distally of plate **812**. As shown in FIG. **7**A, cables **804** may be Bowden cables. Distal portions **808** of cables **804** may lack an outer covering or sheath of more proximal portions of cables **804** where cables **804** are Bowden cables. Alternatively, cables **804** may be other types of cables or wires, and distal portions **808** may be uniform to a remainder of cables **804**. Although two cables **804** are shown, it will be appreciated that other numbers of cables **804** (e.g., four) may be used.

A distal end of cables **804** may be coupled to a detangling element **820**. Detangling element **820** may include a plate **830** and a ring **822**. Ring **822** may be received within opening of plate **830** and may be rotatable relative to plate **830**. A rim of ring **822** may be on a distal side of plate **830**. Ball bearings may be disposed between ring **822** and plate **830** in order to ease rotation between ring **822** and plate **830**. Ring **822** may have arms **824** that extend proximally, through the opening of plate **830**. Arms **824** may define slots for receiving cables **804** (e.g., for receiving distal portions **808**). A distal end of cables **804** may include a cap **826** (e.g., a rounded, protruding end of cables **804**) to retain each of cables **804** within the slots of arms **824**.

Cables **802** may extend through a distal tip of a duodenoscope or other endoscope (such as any of the distal tips described herein). Cables **802** may extend through or may be fixed to a plate **810**. Alternatively, plate **810** may be omitted. Plate **810** may be a portion of a distal tip (e.g., a proximal face of the distal tip). Proximal portions **806** of cables **802** may extend proximally of plate **810**. As shown in FIG. **7**A, proximal cables **802** may be Bowden cables, and proximal portions **806** may include wires or cables of the Bowden cables without an exterior sheath/covering. Although two cables **802** are depicted, it will be appreciated that alternative numbers (e.g., four) cables may be utilized.

Plate **830** of detangling element **820** may define slots **832** for receiving cables **802** (such as proximal portions **806**). A proximal end of cables **804** may include a cap (e.g., a rounded, protruding end of cables **802**, which may have any of the properties of cap **826**) to retain each of cables **802** within the slots of plate **830**.

Because ring **822** may be rotatable relative to plate **830**, cables **802** may be rotated about an axis of detangling element **820** without rotating cables **804**, thereby avoiding tangling of cables **804** (or cables **802**) due to twisting of the cables. Detangling element **820** may have properties (e.g., conductivity) or may have features (e.g., traces) that allow communication of cables **804** and cables **802**, via detangling element **820**. Alternatively, cables **802**, **804** may be articulation wires/cables that allow steering of a distal end of the shaft. Where the cables **802**, **804** are articulation wires, it will be appreciated that additional cables may also be utilized so as to provide up/down/left/right articulation. Additional cables may have properties like those of cables **802**, **804** and may interface with detangling element **820** in similar manners.

Detangler **860** may also include rings **814** (on a sheath side of detangling element **820**) and rings **816** (on a distal tip side of detangling element **820**), which may facilitate installation of detangler **860** and may mate with elements of the duodenoscope and/or the detangler **860**. For example, ring **814** may fit in a central opening of ring **822** and may be fixed to plate **812**. In such a configuration, ring **814** may facilitate positioning of plate **812** relative to detangling element **820**. Ring **814** may additionally or alternatively form seals.

Only some aspects of a detangler **860** may be used along with the duodenoscope or other endoscope. For example, detangling element **820** (or a similar structure having the same or similar functions) may be used, but plates **812** and **810** may be omitted. Detangler **860** may be used in conjunction with other aspects described herein (e.g., with the motors of distal tip **600** of FIGS. **6**A and **6**B).

FIGS. **7**B and **7**C show aspects of a duodenoscope **900** that may have rotation features, which may be used in conjunction with detangler **860** or distal tip **600** or with other elements described herein. FIG. **7**C shows an exploded view of the device of FIG. **7**B. Duodenoscope **900** may include a shaft **918**, which may have any of the properties of the shafts described herein (e.g., shaft **18**). Duodenoscope **900** may have a distal tip **901** having any of the properties of the distal tips described herein. Distal tip **901** may have a viewing element **902** and a lighting element **904**, having any of the properties of the other viewing elements and lighting elements described herein. Distal tip **901** may also have an elevator **910**, having any of the features of the elevators described herein.

Distal tip **901** may be joined to shaft **918** via a rotation bearing **960**. Rotation bearing **960** may include a stationary plate **962** and a rotating plate **964**, which may be detachable from one another. Rotating plate **964** may rotate 360 degrees (or less than 360 degrees) relative to stationary plate **962**. Rotation bearing **960** may be used with any of the exemplary distal tips described herein in order to facilitate rotation of the distal tip relative to a duodenoscope shaft or vice versa. Rotation bearing **960** may be, for example, a lazy Susan-type bearing. Rotation bearing **960** may have any of the properties of detangling element **820**, described above, which also includes two components (plate **830** and ring **822**) that are rotatable relative to one another. Cables may be secured to rotation bearing **960** in a similar manner to

detangler **860**, described above. For example, cables of shaft **918** may be secured to stationary plate **962**, and cables of distal tip **901** may be secured to rotating plate **964**.

While principles of the present disclosure are described herein with reference to illustrative examples for particular applications, it should be understood that the disclosure is not limited thereto. Those having ordinary skill in the art and access to the teachings provided herein will recognize additional modifications, applications, and substitution of equivalents all fall within the scope of the examples described herein. Accordingly, the invention is not to be considered as limited by the foregoing description.

We claim:

1. A medical device, comprising:

a distal tip having:

a viewing element,

a lighting element,

at least one mating component configured to removably couple the distal tip to a shaft, and

an elevator control wire for raising and lowering an elevator of an endoscope, wherein a proximal end of the elevator control wire is at a distal end of the medical device and includes a notch configured to mate with a protrusion of a sleeve that extends around a distal portion of a shaft elevator control wire;

a working channel fixedly coupled to the distal tip and defining a central lumen configured to receive a tool, wherein a wall of the working channel defines at least one additional lumen, and wherein the working channel is configured to be removably inserted into the shaft; and

at least one of a wire, a cable, or a conduit passing through the at least one additional lumen.

2. The medical device of claim **1**, wherein at least one of the wire, the cable, or the conduit includes the wire or the cable, and wherein the wire or the cable is configured to operate at least one of an elevator of the distal tip, the viewing element, or the lighting element.

3. The medical device of claim **2**, wherein the distal tip further includes a motor operative to raise or lower the elevator.

4. The medical device of claim **3**, wherein at least one of the wire, the cable, or the conduit includes the wire or the cable, and wherein the wire or the cable is configured to provide power to the motor.

5. The medical device of claim **1**, wherein the wall of the working channel defines at least two additional lumens.

6. The medical device of claim **1**, wherein the at least one mating component includes at least one peg extending from a proximal surface thereof.

7. The medical device of claim **1**, wherein the distal tip is configured to be rotatable relative to the shaft.

8. The medical device of claim **1**, wherein the distal tip includes a motor configured to rotate the distal tip relative to the shaft.

9. The medical device of claim **8**, wherein the motor is configured to rotate a gear, and wherein the distal tip includes teeth configured to engage with the gear.

10. The medical device of claim **1**, wherein a proximal end of the working channel includes a plurality of threads for securing the proximal end to a handle at a proximal end of the shaft.

11. The medical device of claim **1**, wherein a proximal end of the distal tip defines a port for operatively connecting an electronic element of the distal tip to one of the wire, the cable, or the conduit extending through the shaft.

12. A method comprising:

detachably coupling a distal tip to a shaft of a medical device, the distal tip having:

a viewing element, and

a lighting element;

feeding a working channel, coupled to the distal tip, through the shaft from a distal end of the shaft to a proximal end of the shaft, wherein a proximal portion of the working channel includes a plurality of threads,

detachably coupling the proximal portion of the working channel to a handle of the medical device via the plurality of threads; and

at a distal end of the medical device, detachably coupling a notch of an elevator control wire to a protrusion of a sleeve that extends around a distal portion of a shaft elevator control wire, wherein the elevator control wire raises and lowers an elevator of the medical device.

13. The method of claim **12**, wherein the working channel defines a central lumen configured to receive a tool, wherein a wall of the working channel defines at least one additional lumen, wherein at least one of a wire, a cable, or a conduit passes through the at least one additional lumen, wherein at least one of the wire, the cable, or the conduit is configured to be operatively connected to at least one of the viewing element, the lighting element, or a nozzle.

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